Pearson Edexcel International Advanced Level

Friday 5 June 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WPH15/01A**

Physics

International Advanced Level

UNIT 5: Thermodynamics, Radiation, Oscillations and Cosmology

Question Paper

You must have:
Scientific calculator and Answer Book (sent separately).
Do not return this question paper with the Answer Book.

Information

- The list of data, formulae and relationships is printed at the end of this Question Paper.

Turn over

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Pearson

SECTION A

Answer ALL questions.

1 Which of the following statements is a correct description of the binding energy of a nucleus?

A The energy released when the nucleus forms from individual nucleons.

B The energy released when radiation is emitted from the nucleus.

C The energy required to overcome the force between nucleons.

D The energy required to form the nucleus from individual nucleons.

(Total for Question 1 = 1 mark)

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2 A student used a GM-tube and counter to measure the count near a radioactive source for one minute. He used this value to calculate the count rate due to the radioactive source.

Which of the following would decrease the percentage uncertainty in the student's value for the count rate?

A Add the background count to the measured count.

B Increase the counting time to 10 minutes.

C Increase the distance of the GM-tube from the source.

D Decrease the counting time to 30 s.

(Total for Question 2 = 1 mark)

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3 About 25% of the mass of our Universe is thought to consist of 'dark matter'.

Which of the following is a correct statement about dark matter?

A It absorbs all electromagnetic radiation.

B It does not emit electromagnetic radiation.

C It does not exert a gravitational force.

D It does not have mass.

(Total for Question 3 = 1 mark)

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4 A mass is oscillating with amplitude A.

Energy is transferred to the mass and the maximum kinetic energy of the mass doubles.

Which of the following is equal to the new amplitude of oscillation?

A $\frac{A}{2}$

B $\frac{A}{\sqrt{2}}$

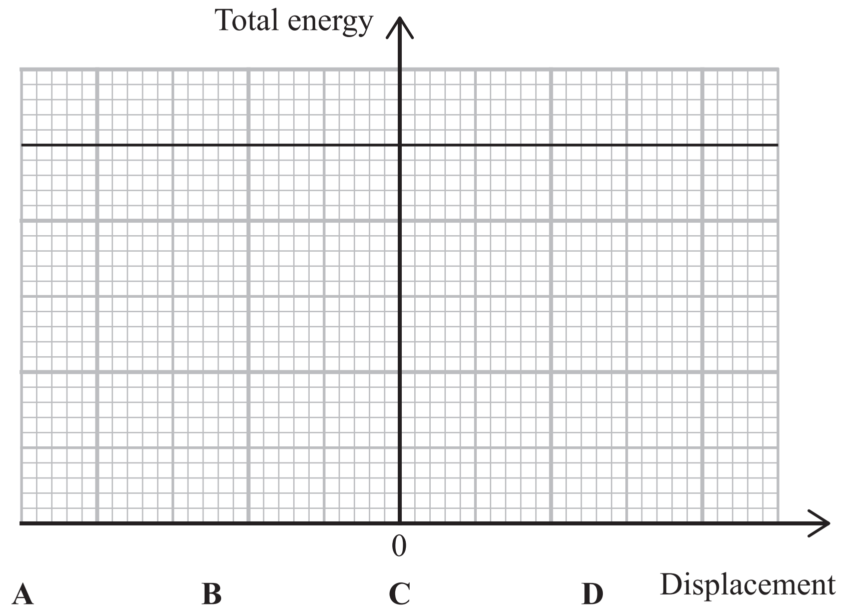
C $\sqrt{2}A$

D $2A$

(Total for Question 4 = 1 mark)

5 A mass is oscillating with undamped simple harmonic motion.

The graph shows how the total energy varies with displacement.



Which displacement, **A**, **B**, **C** or **D**, corresponds to the position at which the kinetic energy of the mass is equal to the total energy?

(Total for Question 5 = 1 mark)

6 The gravitational field strength at the surface of the Earth is $9.8\,\mathrm{N\,kg^{-1}}$. A satellite is orbiting at a height above the surface of the Earth equal to the radius of the Earth.

Which of the following is the gravitational field strength in $\mathrm{N\,kg^{-1}}$ at this height?

A 1.1

B 2.5

C 3.3

D 4.9

(Total for Question 6 = 1 mark)

---

7 A mass is hanging in equilibrium from a spring. The mass is displaced vertically 5 cm from the equilibrium position and then released.

The time for the mass to travel back to the equilibrium position is 0.8 s.

Which row of the table is correct?

	Amplitude of oscillation / cm	Period /s
A	5	1.6
B	5	3.2
C	10	1.6
D	10	3.2

(Total for Question 7 = 1 mark)

---

8 A mass is hung from a spring and set into vertical oscillation.

Which of the following is correct?

A The resultant force always acts in the same direction as the velocity.

B The resultant force always acts in the opposite direction to the velocity.

C The resultant force always acts in the same direction as the displacement.

D The resultant force always acts in the opposite direction to the displacement.

(Total for Question 8 = 1 mark)

9 The gravitational field strength on the surface of Mars is g. The Moon has the same density as Mars but only half the radius.

Which of the following is the gravitational field strength on the surface of the Moon?

A $\frac{g}{4}$

B $\frac{g}{2}$

C $2g$

D $4g$

(Total for Question 9 = 1 mark)

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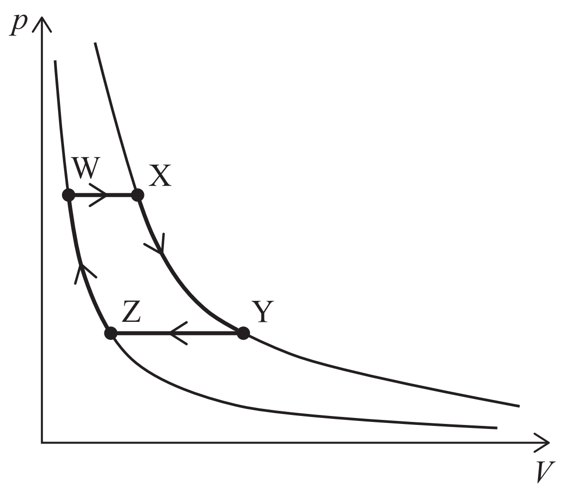
10 A fixed mass of an ideal gas is made to expand and then contract in a cycle W → X → Y → Z → W.

The pressure p exerted by the gas varies with the volume V occupied by the gas, as shown.



Which row of the table shows the stage of the cycle with the corresponding change in temperature?

	Stage of cycle	Temperature
A	W → X	increases
B	W → X	stays the same
C	Y → Z	increases
D	Y → Z	stays the same

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in this section in the spaces provided in the Answer Book.

11 Canopus is one of the brightest stars in the night sky. The intensity of Canopus is measured to be $5.92 \times 10^{-5}\,W\,m^{-2}$.

Calculate the luminosity of Canopus.

distance of Canopus from the Earth = $2.93 \times 10^{18}\,m$

(Total for Question 11 = 2 marks)

---

12 A fruit drink is made by mixing 75 g of raspberry juice with 220 g of water.
The initial temperature of the raspberry juice is 11.5 °C and the initial temperature of the water is 100 °C.

Calculate the final temperature of the fruit drink.

specific heat capacity of raspberry juice = $3890\,J\,kg^{-1}\,°C^{-1}$
specific heat capacity of water = $4190\,J\,kg^{-1}\,°C^{-1}$

(Total for Question 12 = 3 marks)

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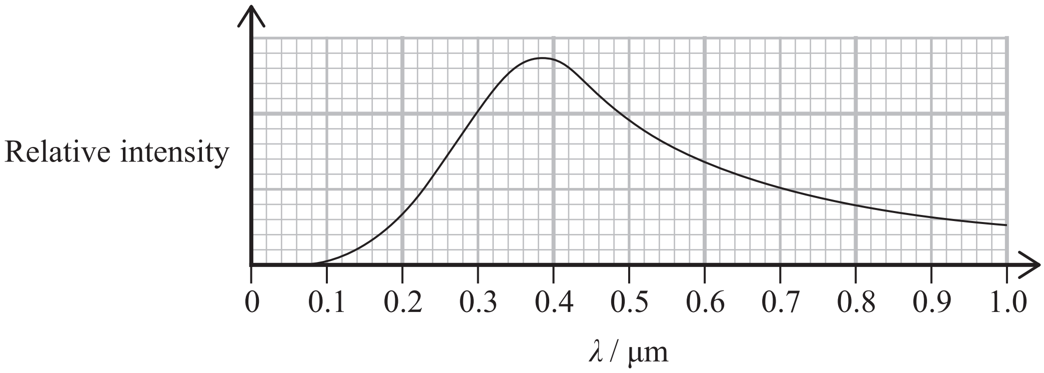
13 A graph of relative intensity against wavelength λ for star X is shown.



The table shows the surface temperatures of three stars.

Star	**Surface temperature / K**
Procyon A	6500
Virginis A	7500
Altair	7800

Deduce the identity of star X.

(Total for Question 13 = 4 marks)

14 Radium is an unstable isotope that decays into radon, as shown in the nuclear equation.

$$^{224}_{88}\mathrm{Ra} \rightarrow \, ^{220}_{86}\mathrm{Rn} + \, ^{4}_{2}\alpha$$

14 (a) The table below gives the masses of the nuclei.

Nucleus	**Mass / u**
$^{224}_{88}\mathrm{Ra}$	224.02021
$^{220}_{86}\mathrm{Rn}$	220.01138
$^{4}_{2}\alpha$	4.00260

Calculate the energy in MeV released in the decay.

(5)

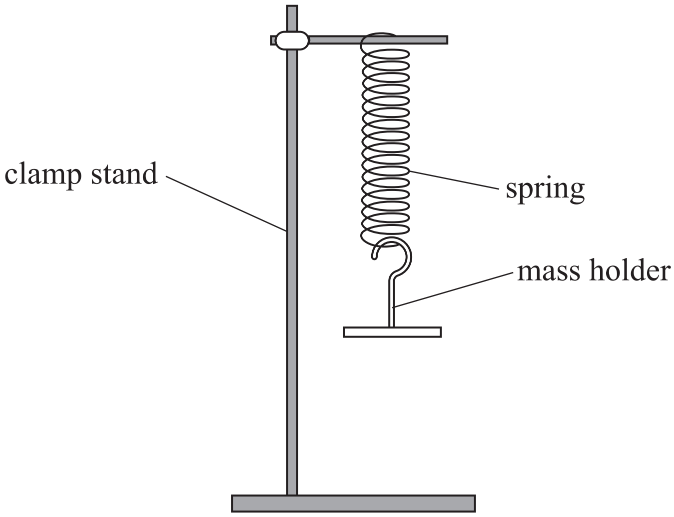
14 (b) The decay of unstable isotopes in rocks produces radon gas. Radon is unstable and emits alpha particles.

Explain why radon gas is dangerous to people.

(2)

(Total for Question 14 = 7 marks)

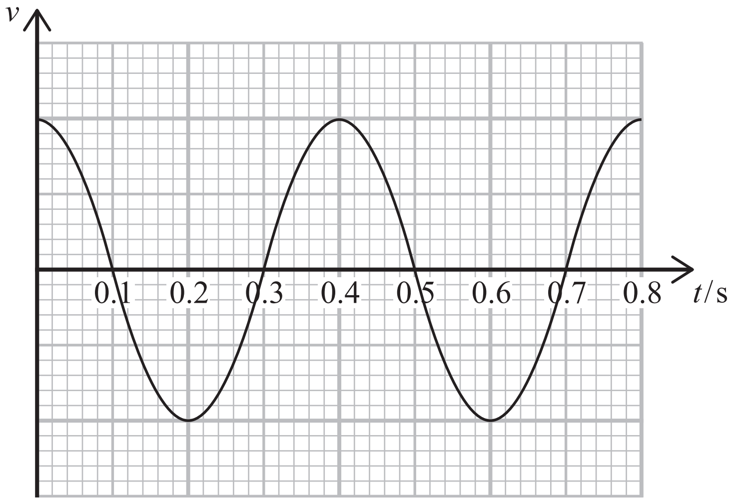
15 A student suspended a mass holder, of mass m, from a spring, as shown.



The student displaced the mass holder from its equilibrium position. He released the mass holder and it oscillated vertically.

The student used a velocity sensor connected to a data logger to record how the velocity of the mass holder changed with time.

15 (a) The graph shows how the velocity of the mass holder varied with time.



15 (a) (i) Add a line to the graph in the Answer Book to show how the displacement of the mass holder varied with time during the same time interval.

(2)

15 (a) (ii) Determine the stiffness of the spring.

$m = 0.125\,\text{kg}$

(3)

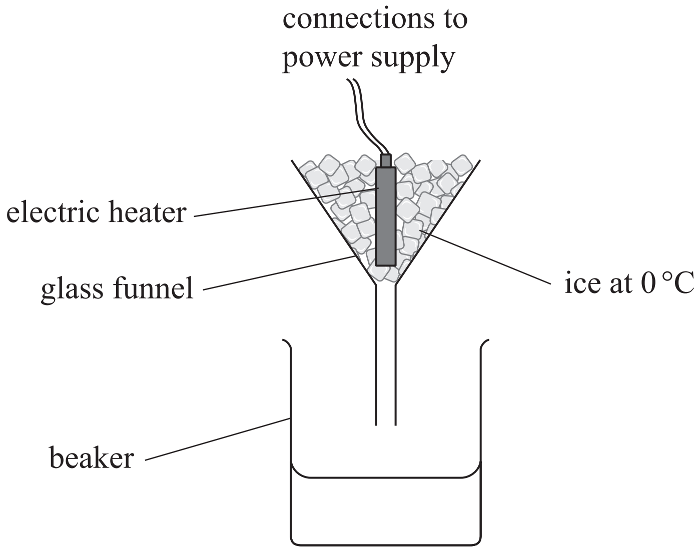
15 (b) Data loggers can be used to collect data in many different experimental situations.

Give **two** experimental situations when using a data logger leads to more accurate data.

(2)

(Total for Question 15 = 7 marks)

16 A student used the apparatus shown to determine the specific latent heat of ice.



16 (a) The beaker was initially empty. The student switched the heater on for exactly 750 s and water collected in the beaker. The final mass of the beaker and water was 270 g.

Calculate a value for the specific latent heat of ice.

potential difference across heater = 24 V
current through heater = 2.3 A
mass of empty beaker = 150 g

(3)

16 (b) The student's data gives a value for the specific latent heat of ice that is too large.

Suggest why the student's value may be too large.

(1)

(Total for Question 16 = 4 marks)

17 Potassium chloride contains a radioactive isotope of potassium K. This decays into an isotope of calcium Ca by beta decay.

17 (a) Complete, in the Answer Book, the nuclear equation for this decay.

(2)

$$^{40}_{19}\mathrm{K} \rightarrow \;^{\cdots\cdots}_{\cdots\cdots}\mathrm{Ca} + \;^{\cdots\cdots}_{\cdots\cdots}\beta^{-} + \;^{0}_{0}\overline{\nu}$$

17 (b) A sample of potassium chloride has an initial activity of 1.90×10^{5} Bq.

half-life of ^{40}K = 1.25×10^{9} years
1 year = 3.15×10^{7} s

17 (b) (i) Calculate the initial number of atoms of ^{40}K in the sample.

(3)

17 (b)(ii) A teacher claims that after 75 years, the activity of this sample would be less than the activity of a typical school radioactive source.

Deduce whether this claim is correct.

activity of school radioactive source = 1.85×10^{5} Bq

(3)

(Total for Question 17 = 8 marks)

18 The internationally recognised basketball rules are specified by the International Basketball Federation (FIBA).

18 (a) According to FIBA, the pressure of the air in the basketball must be between 45 kPa and 52 kPa above atmospheric pressure. The circumference of the basketball must be 75 cm.

A basketball was inflated with air at a temperature of 16.0 °C. When fully inflated, the basketball contained 2.50×10^{23} molecules of air. The circumference of the basketball was 75 cm.

Deduce whether this basketball met FIBA rules.

atmospheric pressure = 1.05×10^{5} Pa

(6)

***18** (b) As the temperature of the air inside a basketball decreases, the pressure decreases.

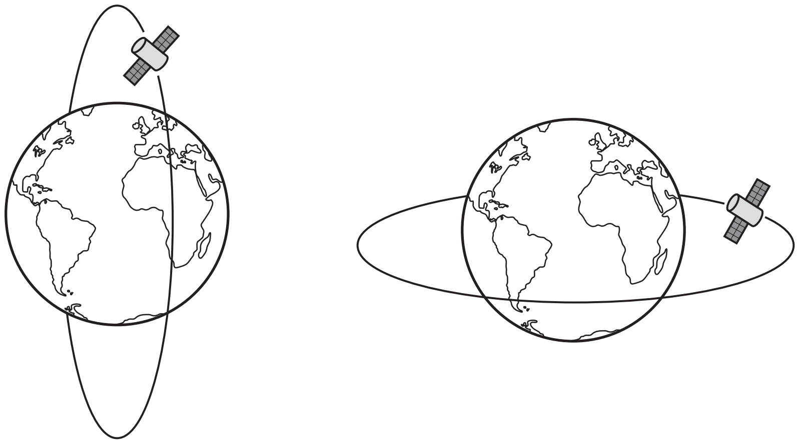
Explain why the pressure decreases.

You should refer to the motion of the molecules of air and assume that the volume of the basket ball remains constant.

(6)

(Total for Question 18 = 12 marks)

19 Satellites may be in an orbit around the North and South poles of the Earth, or in an orbit around the equator, as shown.



orbit around the poles   orbit around the equator

19 (a) A satellite in orbit around the poles has a height of 8.50×10^5 m above the surface of the Earth.

19 (a) (i) Show that the gravitational potential at this height is about $-5.5 \times 10^7\,\mathrm{J\,kg^{-1}}$.

mass of Earth = 5.98×10^{24} kg
radius of Earth = 6.36×10^6 m

(2)

19 (a)(ii) A satellite is moved from the surface of the Earth to this height.

Calculate the increase in gravitational potential energy of the satellite.

mass of satellite = 145 kg
gravitational potential at the surface of the Earth = $-6.27 \times 10^7\,\mathrm{J\,kg^{-1}}$

(2)

19 (b) A geostationary satellite is at the same position above the surface of the Earth at all times. The satellite must be in an orbit around the equator with an orbital period equal to 24 hours.

A satellite is in an orbit around the equator. The radius of the orbit is 4.14×10^7 m.

Deduce whether this satellite is a geostationary satellite.

mass of Earth = 5.98×10^{24} kg

(4)

(Total for Question 19 = 8 marks)

20 One hundred years ago the Andromeda Galaxy was thought to be a group of stars within our own galaxy.

20 (a) In 1923, Hubble identified a standard candle within this group of stars.

20 (a) (i) State what is meant by a standard candle.

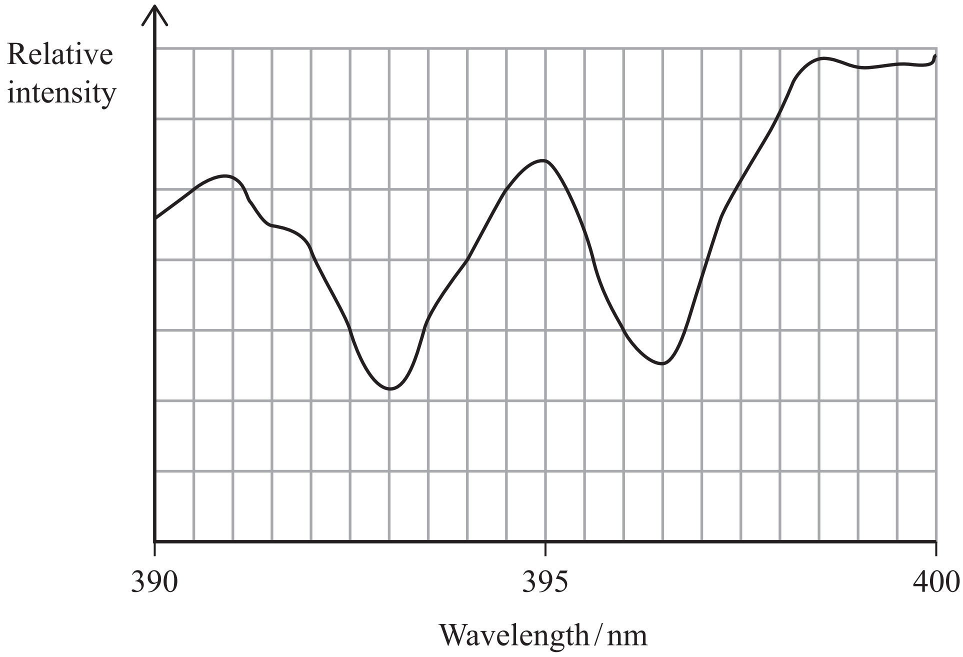
(1)

20 (a) (ii) Describe how astronomers use standard candles.

(3)

20 (b) The radiation received from Andromeda has been analysed.

The graph shows part of the spectrum of radiation received from Andromeda.



Lines in the absorption spectrum of calcium produce the two intensity minima. In the laboratory these two lines have a wavelength of 393.4 nm and 396.9 nm.

Determine the velocity of Andromeda relative to the Earth.

(4)

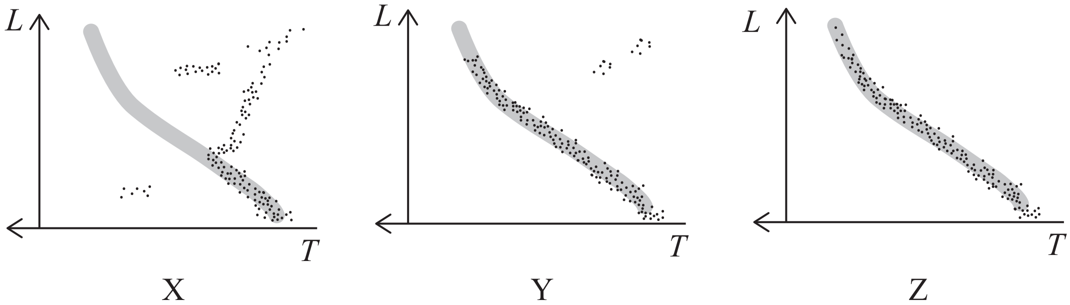
20 (c) Describe how the distances to the most distant galaxies can be determined.

(3)

(Total for Question 20 = 11 marks)

21 The Sun is an average star, mid-way through its lifetime. It is a yellow star with a surface temperature of 5800 K.

21 (a) The Hertzsprung-Russell (HR) diagrams below show a group of stars at different stages of evolution. L is luminosity and T is temperature.
The diagrams are **not** in time order.



Explain which HR diagram shows the group of stars at the earliest stage of its evolution and which HR diagram shows the group of stars at the latest stage of its evolution.

You should refer to the diagrams in your answer.

(4)

21 (b) Fusion of hydrogen H in the core of the Sun releases energy.

The following reaction takes place when two ^{2}H nuclei fuse

$$^{2}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He} + {}^{1}_{0}\text{n}$$

Calculate the energy in MeV released when this reaction takes place.

mass of ^{2}H nucleus = 1.87561 GeV/c^{2}
mass of ^{3}He nucleus = 2.80839 GeV/c^{2}
mass of neutron = 0.93957 GeV/c^{2}

(2)

21 (c) When the Sun has used up the hydrogen in its core, it will evolve into a red giant star.

21 (c) (i) As the Sun becomes a red giant star, its radius will increase from 6.96×10^{8} m to 1.26×10^{11} m. The surface temperature of the Sun will decrease from 5800 K to 3000 K.

As the Sun becomes a red giant star its luminosity L changes.

Calculate the value of $\dfrac{L_{\text{final}}}{L_{\text{initial}}}$

(4)

21 (c)(ii) Explain how the spectrum of radiation emitted by the Sun will change as the Sun becomes a red giant star.

(4)

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

Unit 1

Mechanics

Kinematic equations of motion

$$s = \frac{(u+v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

Efficiency

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Materials

Density $\rho = \dfrac{m}{V}$

Stokes' law $F = 6\pi\eta rv$

Hooke's law $\Delta F = k\Delta x$

Elastic strain energy $\Delta E_{\mathrm{el}} = \dfrac{1}{2}F\Delta x$

Young modulus $E = \dfrac{\sigma}{\varepsilon}$ where

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\dfrac{T}{\mu}}$
Intensity of radiation	$I = \dfrac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \dfrac{c}{v}$
Critical angle	$\sin C = \dfrac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \dfrac{W}{Q}$
Resistance	$R = \dfrac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \dfrac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \dfrac{\rho l}{A}$
Current	$I = \dfrac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \dfrac{h}{p}$

Unit 4

Further mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \dfrac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \dfrac{2\pi}{\omega}$
	$a = \dfrac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \dfrac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \dfrac{F}{Q}$
Coulomb's law	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
Electrical potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \dfrac{Q}{V}$
Energy stored in capacitor	$W = \dfrac{1}{2}QV$
	$W = \dfrac{1}{2}CV^2$
	$W = \dfrac{1}{2}\dfrac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

Resistor-capacitor discharge	$I = I_0 e^{-t/RC}$
	$V = V_0 e^{-t/RC}$
	$\ln Q = \ln Q_0 - \dfrac{t}{RC}$
	$\ln I = \ln I_0 - \dfrac{t}{RC}$
	$\ln V = \ln V_0 - \dfrac{t}{RC}$
In a magnetic field	$F = Bqv \sin \theta$
	$F = BIl \sin \theta$
Faraday's and Lenz's laws	$\mathscr{E} = \dfrac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field	$r = \dfrac{p}{BQ}$
Mass-energy	$\Delta E = c^2 \Delta m$

Unit 5

Thermodynamics

Heating	$\Delta E = mc\Delta\theta$
	$\Delta E = L\Delta m$
Ideal gas equation	$pV = NkT$
Molecular kinetic theory	$\frac{1}{2}m < c^2 > = \frac{3}{2}kT$

Nuclear decay

Mass-energy	$\Delta E = c^2\Delta m$
Radioactive decay	$A = \lambda N$
	$\frac{dN}{dt} = -\lambda N$
	$\lambda = \frac{\ln 2}{t_{1/2}}$
	$N = N_0 e^{-\lambda t}$
	$A = A_0 e^{-\lambda t}$

Oscillations

Simple harmonic motion	$F = -kx$
	$a = -\omega^2 x$
	$x = A\cos\omega t$
	$v = -A\omega\sin\omega t$
	$a = -A\omega^2\cos\omega t$
	$T = \frac{1}{f} = \frac{2\pi}{\omega}$
	$\omega = 2\pi f$
Simple harmonic oscillator	$T = 2\pi\sqrt{\frac{m}{k}}$
	$T = 2\pi\sqrt{\frac{l}{g}}$

Astrophysics and cosmology

Gravitational field strength	$g = \frac{F}{m}$
Gravitational force	$F = \frac{Gm_1m_2}{r^2}$
Gravitational field	$g = \frac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma AT^4$
Wien's law	$\lambda_{max}T = 2.898 \times 10^{-3}\,\mathrm{m\,K}$
Intensity of radiation	$I = \frac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$
Cosmological expansion	$v = H_0 d$

Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Friday 5 June 2026

Morning (Time: 1 hour 45 minutes) | Paper reference **WPH15/01A**

Physics

International Advanced Level
UNIT 5: Thermodynamics, Radiation, Oscillations and Cosmology
Answer Book

You must have:
Scientific calculator and question paper (sent separately).

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of the question paper.

Advice

- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

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P 8 7 9 4 5 A 0 1 2 0

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SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 1 = 1 mark)

2

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 2 = 1 mark)

3

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 3 = 1 mark)

4

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 4 = 1 mark)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

5

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 1 mark)

6

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 1 mark)

7

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

8

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 1 mark)

9

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 9 = 1 mark)

10

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

SECTION B

Answer ALL questions in the spaces provided.

11

Luminosity of Canopus = ...

(Total for Question 11 = 2 marks)

12

Final temperature of the fruit drink = ...

(Total for Question 12 = 3 marks)

13

(Total for Question 13 = 4 marks)

14 (a)

(5)

Energy released = ... MeV

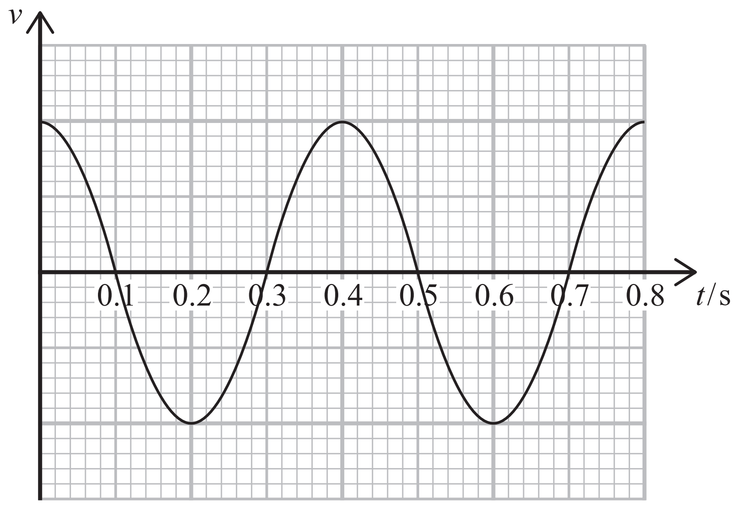
14 (b)

(2)

(Total for Question 14 = 7 marks)

15 (a) (i)

(2)



15 (a)(ii)

(3)

....

....

....

....

....

....

Stiffness of spring = ...

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

15 (b)

(2)

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....

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....

(Total for Question 15 = 7 marks)

16 (a)

(3)

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....

specific latent heat of ice = ...

16 (b)

(1)

....

....

....

....

(Total for Question 16 = 4 marks)

DO NOT WRITE IN THIS AREA

17 (a)

(2)

$$^{40}_{19}\text{K} \rightarrow \,^{\ldots\ldots}_{\ldots\ldots}\text{Ca} + \,^{\ldots\ldots}_{\ldots\ldots}\beta^{-} + \,^{0}_{0}\overline{\nu}$$

17 (b) (i)

(3)

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....

initial number of atoms = ...

17 (b)(ii)

(3)

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....

(Total for Question 17 = 8 marks)

18 (a)

(6)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

*18 (b)

(6)

(Total for Question 18 = 12 marks)

19 (a) (i)

(2)

19 (a)(ii)

(2)

Increase in gravitational potential energy = ...

19 (b)

(4)

(Total for Question 19 = 8 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

20 (a) (i)

(1)

....

....

20 (a) (ii)

(3)

....

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20 (b)

(4)

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Magnitude of velocity = ...

Direction of velocity ....

20 (c)

(3)

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(Total for Question 20 = 11 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

21 (a)

(4)

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21 (b)

(2)

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....

Energy released = ... MeV

21 (c) (i)

(4)

$\frac{L_{final}}{L_{initial}} =$ ....

21 (c)(ii)

(4)

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

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